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The Effect of Mammalian Cell Functionalization with Polycation and Halloysite Nanotubes on Intercellular Interactions

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Abstract This paper describes the formation of a cytoprotective frame on mammalian cells and determines its impact on cell viability and creation of 3D tissue-like structures from cells modified by halloysite nanotubes and a polycation. Using the "hanging drop" method, spheroids were obtained from unmodified cells and cells modified with halloysite nanotubes and poly(acrylamide-co-diallyldimethyl-ammonium chloride). It has been shown that layer-by-layer modification of eukaryotic cells with the natural mineral halloysite and the polymer has little effect on their physiological parameters. Probably, the functionalization of the surface of cells by the nanoframe can be used for their protection from lethal factors, as well as for targeted drug delivery.

Keywords Human cells · Halloysite nanotubes · Cell functionalization · ZO1

1 Introduction

It is known that both microbial cells and bacteria have a protection layer on their surface [1], which guards them from adverse environmental conditions. Mammalian cells do not have a reliable external overcover and are sheathed only by a lipid bilayer membrane, which is very susceptible towards conditional changes. It is worth remarking that the mechanical fragility of mammalian cells significantly complicates their chemical treatment, and due to this many in vitro tests are difficult to implement or require long-term and costly procedures aimed at maintaining cell viability [2]. The formation of a cytoprotective scaffold from durable materials on the surface of mammalian cells is promising for various assay systems, cell therapy, regenerative medicine, as well as for basic research in the field of cell biology. The scientific literature does not abound with information as to how to create the scaffolds for mammalian cells using mineral halloysite nanotubes. The natural mineral halloysite is readily available and is of particular importance for nanomedicine and pharmaceuticals as one is capable of carrying different drugs on inner and inter surfaces and to hold them, increasing the stability of the drug or changing the rate of its release [3]. Polyelectrolytes are often used in cell surface engineering studies to create a uniform coating and reliable fastening of nanomaterials [4]. The recent studies bear witness to the fact that the 2D monolayer is limited in simulating the cells' behavior in the tissues of living organisms [5]. In order to realize the specificity of living organism's tissues in vitro, there have been developed various methods for creating 3D cultures, where cells interact with each other and with an extracellular matrix in several planes. 3D cultures are becoming increasingly popular in a variety of research related to cell proliferation, apoptosis, toxicology, differentiation, the development of cancer, etc. [6, 7]. This paper describes the formation of a cytoprotective frame on mammalian cells and determines its impact on cell viability and obtaining the 3D tissue-like structures from cells modified by halloysite nanotubes and a polycation.

2 Material and Methods

The adenocarcinomic human alveolar basal epithelial cells (A549) and human epithelial colorectal adenocarcinoma

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